

# Compensating for the costs of reducing deforestation in Papua New Guinea

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This article examines the abatement in greenhouse gas emissions achievable in Papua New Guinea by a reduction in deforestation and forest degradation (REDD) and its opportunity costs. The total abatement achieved by the cessation of logging for export in 2012 is estimated at between 658 and 788 million tonnes (Mt) of carbon dioxide, at an opportunity cost nationally of between US\$3.40 and US\$5.64/t. Abatement achieved by the cessation of new oil-palm establishment totals between 45 and 113 Mt, at a national cost of about US\$40/t. Stakeholder opportunity costs, as well as national costs, are estimated for logging and oil-palm. Recent work that quantifies emissions from deforestation in Papua New Guinea is integrated with the author's financial models for the logging and palm-oil industries. A fuller understanding is achieved of the complexity of designing and implementing policies for REDD.

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The aim of this article is to estimate the opportunity costs, and hence the compensation, to stakeholders in Papua New Guinea of ceasing or reducing the level of exports of raw logs and of ceasing or reducing the establishment of new oil-palm plantations in favour of reduction in deforestation and degradation (REDD).

Filer et al. (2009) estimate that approximately 293,000 sq km of Papua New Guinea's tropical forests are open to logging and conversion to agriculture and thereby

are a possible source of greenhouse gas emissions. The Kyoto Protocol, however, omits REDD from the suite of mitigation activities that attracts credits under the Clean Development Mechanism (CDM), even though deforestation was thought responsible for about 17 per cent of global greenhouse gas emissions (Canadell et al. 2007; Houghton 2003, 2005) (this estimate has now been revised downwards).<sup>1</sup> There was heightened interest in the role that REDD could play after Stern (2006) reported



that compensating for returns from logging and agriculture could abate emissions at relatively low cost; this notion was reinforced in the case of Papua New Guinea by Howes (2009).

Much effort and speculation followed on how REDD might be included in post-Kyoto arrangements for climate change mitigation under both market and funds approaches. Meanwhile, however, the major emitters—with the exception of the European Union—failed to adopt national emission targets and abatement schemes. As a consequence, the Copenhagen climate change conference in December 2009 was unable to deliver a new protocol to mandate the cuts in emissions that would have stimulated the necessary investment needed for REDD credits to enter the global market. The consequential lack of a global market for carbon emissions has stifled the market for REDD credits and the development of a REDD carbon-accounting system.

While the Copenhagen conference failed to deliver a market mechanism for REDD credits, the Copenhagen Accord (UNFCCC 2009:Clause 5) nevertheless agreed on the need for positive incentives for REDD-plus through a funds approach,<sup>2</sup> enabled by the mobilisation of financial resources from industrialised countries. REDD schemes are limited to deals between forested developing countries and bilateral or multilateral donors, with payments for carbon emissions abated based not on market prices but on what the opportunity costs of abatement might be.

The Copenhagen Accord contains a collective commitment by industrialised countries to provide additional resources for climate change adaptation and mitigation in developing countries, including forestry, approaching US\$30 billion for 2010–12 and rising to US\$100 billion a year by 2020 (UNFCCC 2009:Clause 8). At the same time, Australia, the United States, France, Japan,

Norway and the United Kingdom pledged US\$3.5 billion to support immediate steps to implement the accord (Reuters 2009).

This article focuses on clarifying the costs of REDD to Papua New Guinea and to potential investors. It also reviews some of the key policy issues surrounding the deployment of compensation funds.

## Sources of emissions from land-use change in Papua New Guinea

While Papua New Guinea has taken a national approach to the reduction of emissions—citing transport, power generation, mining and fire as areas where mitigation actions can be taken (Conrad 2010:4)—the country is already a low-carbon economy. The abovementioned sectors provide very limited opportunities for abatement. For example, the latest World Resources Institute (WRI 2010) estimates suggest that less than 10 per cent of Papua New Guinea's emissions are generated by activities other than land-use change and forestry (LUCF).

The major causes of deforestation in Papua New Guinea are commercial agriculture (both estate and smallholder), logging and subsistence or shifting agriculture. In the case of logging and subsistence agriculture, the forest re-grows. The secondary forests that regenerate after logging may or may not be revisited by the logging companies that hold concessions over the area. The secondary forest that follows shifting agriculture will be cleared again, with the length of the fallow interval depending on, among other things, population pressure (Bourke and Harwood 2009).

Shearman et al. (2009:19) estimated that deforestation and degradation released between 146 and 269 million-tonnes (Mt) of carbon dioxide in 2007—32 per cent of which was the result of large-scale logging.



These calculations are, however, overestimates because they ignore the capacity of regenerating forest to reabsorb the carbon dioxide released by deforestation (PNGFIA 2008).

Almost all of Papua New Guinea's land and forests are under customary ownership, and the bulk of the population still depends for its livelihood on indigenous farming systems (Allen et al. 2001). Shearman et al. (2009) assert that subsistence agriculture is a major driver of deforestation. Filer et al. (2009), however, challenge the assumption that areas impacted by harvesting or shifting cultivation will inevitably degrade and become non-forest, because it is not supported by observation of cut-over forest in Papua New Guinea. It is erroneous to assume that both logging and subsistence agriculture lead to permanent deforestation. While there is a loss of carbon from newly logged concessions, plus that from previously logged-over areas and from new village gardens being created, there is a simultaneous and countervailing sequestration of carbon on most of the area previously used (Filer et al. 2009; Keenan et al. 2005). Filer et al. (2009) conclude that the rate of deforestation is much lower than suggested by Shearman et al. (2009).

The government has little or no capacity to change local farming practices, which are characterised by a high degree of innovation, enabling food supply to keep pace with a growing population in most locations (Bourke and Harwood 2009; Filer et al. 2009). Therefore, it is not profitable to speculate on the reduction in carbon emissions that might take place from changes in cultural practices in subsistence or smallholder agriculture. Production of oil-palm, cocoa, coffee and rubber by smallholders has been growing over the past two decades, while estate agriculture has been contracting, except for oil-palm and tea; but, again, there is no comprehensive information on the impacts

of these trends on the carbon cycle. It has been concluded (Filer et al. 2009) that selective logging is the only area in which deforestation can be readily avoided.

The carbon content of Papua New Guinea's tropical native forests has for the first time been the subject of a robust assessment of the aboveground carbon stocks. Fox et al. (2010) discuss the measurement of the carbon in primary forests and in the regenerating forests of different ages at sites across Papua New Guinea, and draw on the work of Bryan et al. (forthcoming), in Fox, Yosi and Keenan (2010:5), to estimate the aboveground carbon in lower mountain forests in Papua New Guinea at 137 t of carbon per hectare (C/ha) and in selectively logged forest at 62 t C/ha.<sup>3</sup> This model accounts for the net emissions from selective logging<sup>4</sup> from 1961 onwards. In the case of oil-palm establishment, Fox et al. (2010) model the historical and future emissions from clearing secondary forest and the absorption of carbon by oil-palm plantations.

## Abatement alternatives in PNG forestry

While this article focuses on the cessation of logging, the feasibility of the enhancement of carbon stock recovery in logged areas through post-harvest reforestation and through reduced-impact logging needs to be discussed, as both activities qualify under REDD-plus.

Logging creates large gaps in the forest canopy, encouraging the growth of low-value pioneer tree species and shrubs. These gaps can be filled with transplants of desirable species—an activity termed enrichment planting or 'reforestation naturally'. Rehabilitation of logged-over areas should enhance the value of regenerating forest, making a second cut



by loggers more economical and more likely. Enrichment planting is, however, hard to justify economically and has not been successful in Papua New Guinea, even though levies have been collected for that purpose. Moreover, such rehabilitation might not increase the sequestration rate of carbon by the forest, given that pioneer species are faster growing than desirable species. And if rehabilitation enables a second cut then the carbon loss and environmental losses incurred are increased.

Selective harvesting generates large quantities of decomposing biomass, including tree crowns, non-merchantable forest and adjacent trees killed, and was found to release 75 t C/ha (Fox, Yosi and Keenan 2010). It is generally recognised that the most effective way to reduce emissions and enhance regeneration is to plan and control the harvesting process. Logging companies, however, see no benefit in reducing collateral damage; the evidence is that adherence to the Logging Code of Practice (PNGFA 1995) has been very patchy (Hunt 2002a).

Payments to logging companies for reducing their carbon emissions through low-impact logging would need to be relative to emissions under the Logging Code of Practice, rather than against emissions under present practice, otherwise moral hazard is an issue. Estimating the abatement achieved in this way is likely to be technically difficult and high cost.

## Aims and methods

In a post-Kyoto protocol that includes a market for REDD credits, the method of carbon accounting and the baseline against which to measure abated emissions will need to be agreed upon. Deforestation is already accounted for under the Kyoto Protocol for Annex I countries. Where deforestation was a net source of emissions

in 1990, the deforestation in the first commitment period—2008–12—is measured against the 1990 level. This is termed ‘net-net’ accounting. In applying REDD to developing countries, the same net-net principle could apply. One of the major obstacles to the inclusion of deforestation in the CDM was the problem of lack of certainty about how much deforestation has been avoided. Baselines are a tool to assess performance in REDD and to determine target levels that go beyond what would have been achieved. Deforestation rates could already be declining in a country and could go on declining as the areas of forest available for profitable agriculture decline. There is a risk in this situation that the baseline will be set too high and REDD will be rewarded for reductions in emissions that would have taken place anyway.

The base periods need to be set over a period long enough to minimise the problems of using remote sensing due to cloud cover and inter-annual variation in deforestation rates. Given the inter-year variability of deforestation within countries, the baseline suggested by Mollicone et al. (2007) is 1990–2005, with the average conversion rate per annum derived from the satellite imagery survey at the start (1990) and the end (2005) of the period. The approach of Mollicone et al. would prevent countries from receiving incentives when global deforestation rates are above the baseline. The net global incentive is apportioned among countries according to their performance.

In a different approach, by Santilli et al. (2005), in heavily logged regions such as Kalimantan et al. for example—where much of the lowland forest has been removed after logging to make way for oil-palm plantations—crediting for increases in carbon stocks in a commitment period could include reforestation or re-growth.



In the absence of an agreed universal method of baseline determination, and the reversion to fund-based REDD initiatives, the method adopted in this article is to assess the abatement achieved by a reduction in deforestation against emissions under business as usual (BAU).

The costing of future emissions abated requires the projection of opportunity costs. The global financial crisis depressed incomes from log exports in 2009, but it is assumed that log prices will recover and follow earlier trends. In discussions between the author and the PNG Forest Industry Association (PNGFIA), consensus was reached on plausible scenarios for 'high', 'medium' and 'low' projections. In the case of palm-oil, projections of production were discussed with the PNG Oil Palm Research Association, and the expansion was expected to continue, while the expected prices for palm-oil are those forecast by the World Bank (2009a).

Having estimated the opportunity costs, the opportunity costs per tonne of carbon dioxide abated can be calculated using Fox, Yosi and Keenan's (2010) data on emissions. The method assumes a cessation of logging and oil-palm establishment in 2012, but it could just as well be used to assess the emissions abatement and opportunity costs of any degree of partial cessation in logging or oil-palm establishment, with the cost per tonne of carbon remaining constant. The net reduction in emissions in any year is the difference between REDD emissions and BAU emissions.

In the absence of logging and new oil-palm plantings, it cannot be assumed that no alternative activity would take place. If some other activity does occur, what is the difference between the economic benefit from this and from forestry and palm-oil production? The opportunity cost in terms of export income is thus derived as Equation 1.

$$\text{Income with REDD} - \text{BAU income} = \text{Opportunity cost of REDD}$$

(1)

To compare the costs of logging and oil-palm, the opportunity costs of REDD per tonne of emissions are derived. Setting the emission reduction as the denominator and the estimates of opportunity costs as the numerator allows the derivation of the costs per tonne of avoided deforestation (Equation 2).

$$\text{Opportunity cost REDD}(\$/\text{Emissions reduction REDD}(t) = \text{Opportunity cost of REDD}(\$/t)$$

(2)

## The discount rate

Cost-benefit analysis of long-term investments is very sensitive to the social rate of discount. There is a case for applying falling discount rates over time to avoid very little weight being placed on events in the distant future (Newell and Pizer 2003; Pearce 2003). Stern (2006) tackled the issue of the discount rate to be applied to very long-term damage from greenhouse emissions, and hence the long-term benefits of mitigation. He argued for a low discount rate, given the risks of experiencing extremely damaging phenomena and the likelihood that impacts of emissions will accelerate as the stock of greenhouse gases increases.

This article, however, deals with income and carbon sequestration streams over a relatively short time. Hepburn and Koundouri (2007) suggest that for short time frames there is no difference between a constant discount rate and a declining discount rate.

The approach to estimating the present cost per tonne of emissions abated—one that is adapted to irregular flows of carbon—is



to apply the social discount rate to each tonne of carbon captured and divide that figure into the present value of opportunity costs. Implicit in this discounting approach is that the real value of the marginal damage caused by a one-tonne increment in atmospheric carbon is constant over time (Richards and Stokes 2004).

There are uncertainties with respect to global markets, climatic factors and PNG policies that could affect BAU incomes. In the case of emissions abated, there are uncertainties associated with the quality of logs extracted, and their carbon content, as logging and oil-palm establishment are forced to exploit dwindling areas of merchantable forests. Therefore, it was felt justified to discount both BAU incomes and the emissions abated at a rate of 10 per cent.

### Estimation of the opportunity costs (BAU incomes) of ceasing logging from 2012

The total of the present value of opportunity costs—in terms of government tax receipts, landowner royalties, landowner development benefits, and profits to logging companies forgone—is in Equation 3. The present value of opportunity cost in terms of exports is in Equation 4. The present value of opportunity cost per tonne of carbon dioxide emitted is in Equation 5, defined as the sum of the discounted costs from Equation 3 divided by the discounted tonnage of carbon dioxide emissions abated.

$$OS = \sum_{n=1}^y (T_n + R_n + D_n + L_n) / (1+r)^n \quad (3)$$

$$EIL = \sum_{n=1}^y EI_n / (1+r)^n \quad (4)$$

$$OCTC = \left\{ \sum_{n=1}^y OS_n / (1+r)^n \right\} / \left\{ \sum_{n=1}^y CO_2 / (1+r)^n \right\} \quad (5)$$

In these equations,  $OS$  = stakeholder opportunity costs;  $T$  = government log export tax receipts;  $R$  = landowner royalties;  $D$  = landowner development benefits;  $L$  = logging company profits;  $EI$  = export income;  $EIL$  = log export income opportunity cost;  $OCTC$  = opportunity cost per tonne of carbon dioxide abated;  $n$  = years (in the case of the 'high' projection,  $y = 14$ ; in the case of the 'medium' projection,  $y = 16$ ; and in the case of the 'low' projection,  $y = 19$ );  $CO_2$  = carbon dioxide emissions abated; and  $r = 0.1$ .

### Estimation of the opportunity costs (BAU incomes), of ceasing palm-oil establishment from 2012

The present value of opportunity costs in the case where oil company profits, smallholder profits and government tax receipts are forgone, is in Equation 6. The present value of costs in the case where palm-oil export income is the opportunity cost is in Equation 7. The present value of opportunity costs per tonne of carbon dioxide emitted





is in Equation 8, which is the sum of the discounted costs from Equation 6 divided by the discounted tonnage of carbon dioxide emissions abated.

$$OS = \sum_{n=1}^{28} (CP_n + S_n + T_n) / (1+r)^n \quad (6)$$

$$EIP = \sum_{n=1}^{28} EI_n / (1+r)^n \quad (7)$$

$$OCTC = \left\{ \sum_{n=1}^{28} OS_n / (1+r)^n \right\} / \left\{ \sum_{n=1}^{28} CO_{2n} / (1+r)^n \right\} \quad (8)$$

New variables are defined as:  $CP$  = palm-oil company net profits;  $S$  = smallholder net profits;  $T$  = government income tax receipts;  $EIP$  = export income opportunity cost for palm-oil.

In the case of log and palm-oil exports, Papua New Guinea is a price taker, but no account has been taken of commodity price increases resulting from global efforts to halt deforestation. Another uncertainty is the effect of the massive liquefied natural gas (LNG) project and other resource projects that will increase foreign currency inflows and, eventually, tax revenues. Avoidance of 'Dutch disease' from kina appreciation that will reduce the incomes from logs and palm-oil could require the saving of revenues in an offshore trust fund (ACIL Tasman 2009; PNG Department of Treasury and Finance 2009).

In the event of a cessation of or reduction in logging and oil-palm, the incomes of landowners will diminish. Landowners can be expected to compensate for a reduction

in their incomes by increasing subsistence agriculture (ITS Global 2009 also suggests that subsistence agriculture will increase). They will likely do this by intensifying production or shortening their rotations (see Bourke and Harwood 2009 for a discussion of food-crop production increases in Papua New Guinea).

Moreover, biodiversity could increase, and this could lead to enhanced benefits from eco-tourism. It was impossible, however, to estimate the extent and value of these alternative income sources within the scope of this article. Given that the income with REDD is assumed to be zero, the opportunity cost is set equal to BAU income.

In estimating the future stream of income from logging, it is necessary to take into account market conditions for raw logs and the future availability of the resource to logging companies. The market for raw logs has been impacted since mid 2008 by the global financial crisis, but PNG production under a BAU scenario is expected to recover and plateau at almost 3 million cu m. In making this forecast, forest industry personnel were consulted (Personal communication, Bob Tate, executive officer, Forest Industries Association Incorporated, and members of the PNGFIA board, December 2009) for their views. The consensus was that because of the increasing costs of logging and diminishing profitability, the volume of log exports is likely to recover but only to a modest degree—similar to that modelled in Figure 1, where the dip in exports in 2008 and 2009 is due to the global financial crisis. In this 'medium' projection, 2.5 million cu m of raw logs is extracted for export and 500,000 cu m is for domestic processing. In assessing opportunity costs, a sensitivity analysis was conducted with income from export logs also at 'high' and 'low' levels. A REDD scheme is assumed to be designed to reduce the export of raw



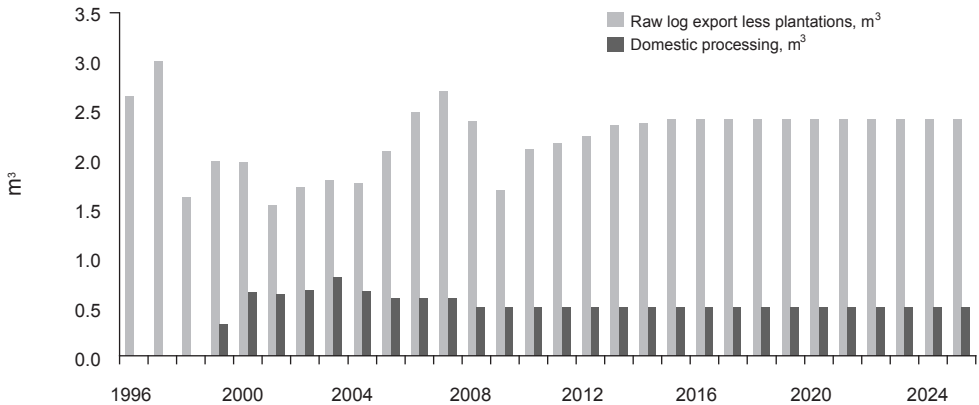
logs but not the production of logs for the domestic market; a reduction in the latter would have greater consequences for employment and affect the supply of timber in the domestic market.

The free-on-board (FOB) value of export logs and the shares of this income to stakeholders, logging companies, landowners and government—both historically and under a BAU scenario—together with the value of processed product, are calculated (Figure 2) (please contact the author at [c.hunt@uq.edu.au](mailto:c.hunt@uq.edu.au) for actual and projected stakeholder incomes). While this analysis includes the log export tax, it does not include income tax paid by logging companies—their annual accounts being publicly unavailable. The logging company share in Figure 2 is the difference between total receipts and landowner receipts plus government receipts.

The compulsory levies that apply to log exports, which determine the shares of log export income to government, landowners and logging companies, are complex, and are summarised in Appendix 1.

Despite the compulsory nature of export levies, establishment of the benefits received by landowners from the exploitation of their forest resources is made difficult by the negotiability of the project development benefits (PDBs)—both in respect to the proportion of cash and project funds and to the degree to which permit holders make cash payments as a supplement to or as a substitute for project funds. The Review Team (2004) estimated that the total value of landowner benefits in operational logging projects was K26/cu m of log exports, which is only slightly above the royalty plus the PDB payment estimated by the author to be between K20/cu m and K23/cu m for the years 2002–04.

**Figure 1** Volume of raw logs exported and processed, actual to 2008, medium BAU projected to 2025



**Sources:** Raw log exports actual—Bank of Papua New Guinea (BPNG), Various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby; processing—Papua New Guinea Forest Industries Association (PNGFIA), n.d. *Key Indicators 1992–1994*, Papua New Guinea Forest Industries Association, Port Moresby. Available from [http://www.fiapng.com/forest\\_sector.html](http://www.fiapng.com/forest_sector.html) (accessed October 2009); Papua New Guinea Forest Authority (PNGFA), 2007. *Papua New Guinea Forest Authority 2006 Annual Report*, Papua New Guinea Forest Authority, Port Moresby; BAU projections—Colin Hunt.





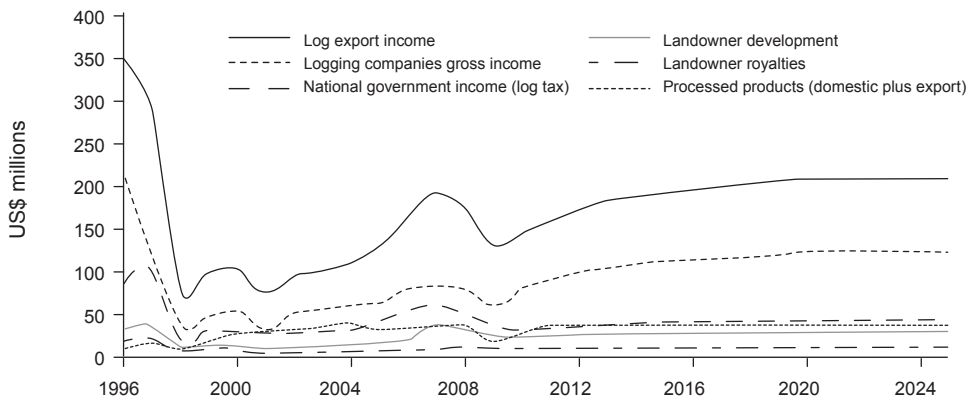
A conservative approach is taken to the estimation of the benefits received by land-owners from the logging of natural forests. No allowance is made for in-kind and cash benefits over and above compulsory royalty and development levies; in other words, it is assumed that such benefits substitute for development levies.

Fox, Yosi and Keenan (2010) estimate that, on average, selectively harvested forest has 75t C/ha less aboveground live biomass than primary forest immediately after harvesting.<sup>5</sup> The Fox, Yosi and Keenan (2010) model of carbon dioxide (the main

greenhouse gas) emissions takes account of not only the removal of biomass in the form of logs but also the carbon dioxide emitted by the decomposition of small wood and large wood resulting from collateral damage, emissions from timber harvesting and transport operations, together with the rate of carbon sequestration in areas of successful forest regeneration as well as the storage of carbon in wood products.

Actual and modelled abated emissions, under the medium BAU scenario, are in Figure 3. In 2019, emissions from BAU logging reach 48.6 Mt of carbon dioxide (CO<sub>2</sub>).

**Figure 2 Income from raw log exports and domestic processing, actual to 2008, medium BAU projected to 2025**



**Sources:** Actual log export income—Bank of Papua New Guinea (BPNG), Various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby. Landowner development levy and royalty to 2006—Hunt, C., 2002b. 'Efficient and equitable forest rent capture in three Pacific island nations: opportunities and impediments in forest policy reform', *Small-Scale Forest Economics, Management and Policy*, 1(1):Table 4; Hunt, C., 2006. An economic assessment of present and alternative arrangements for the management of PNG forests, Unpublished report:Table 2; Papua New Guinea Forest Authority (PNGFA), 2007. *Papua New Guinea Forest Authority 2006 Annual Report*, Papua New Guinea Forest Authority, Port Moresby:23; Papua New Guinea Forest Industries Association (PNGFIA), 2007. PNG forest sector—an overview, Presentation by R. Tate to the 42nd meeting of the International Tropical Timber Council, Port Moresby. Landowner development levy and royalty 2007 and 2008 estimation based on legislated levy and royalty. Processed products—Bank of Papua New Guinea (BPNG), Various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby; Papua New Guinea Forest Industries Association (PNGFIA), 2007. PNG forest sector—an overview, Presentation by R. Tate to the 42nd meeting of the International Tropical Timber Council, Port Moresby; Papua New Guinea Forest Industries Association (PNGFIA), n.d. *Key Indicators 1992–1994*, Papua New Guinea Forest Industries Association, Port Moresby. Available from [http://www.fiapng.com/forest\\_sector.html](http://www.fiapng.com/forest_sector.html) (accessed October 2009); Papua New Guinea Forest Authority (PNGFA), 2007. *Papua New Guinea Forest Authority 2006 Annual Report*, Papua New Guinea Forest Authority, Port Moresby; BAU projections—Colin Hunt.



With a cessation in logging in 2012, however, the emissions are  $-10.5$  Mt due to sequestration in the previously logged forest. The net result in terms of abatement is thus  $59.1$  Mt. The slowly increasing abatement from 2012 is due to the time lag in the release of carbon from forest damaged during logging.

Emissions abated under the 'high', 'medium' and 'low' projections for log volumes and prices are provided (Figure 4); the potential abatement accompanying the 'high' projection stops after 2023 as merchantable logs are exhausted. In contrast, abatement potential under the 'low' projection continues to 2028.

The PNG government benefits from log taxes, while landowners benefit directly from royalties and indirectly from development funds set aside from export revenues (based on the volume and FOB value of logs). The benefits to logging companies are their net profits earned after income tax. But because annual reports of the 20 or so mainly foreign-based logging companies are not publicly accessible, profits are assumed to be 30 per cent of gross incomes, which, it is suggested, is the required return in a high-risk environment such as Papua New Guinea.<sup>6</sup> It is likely that the compensation paid to logging companies would be based on expected profits from concessions awarded by the government. In this analysis, it is assumed that concessions are continually allocated until the merchantable logs are exhausted in 2025 under the 'medium' projection, in 2023 under the 'high' projection, and in '2028' under the low projection. Financial modelling is for the same periods.

The World Bank (2007) emphasised the positive livelihood benefits of improved rural road infrastructure. The economic and social benefits to landowners of infrastructure associated with log harvesting and processing are not confined to roads. Bridges and culverts, airstrips, urban development and forestry plantations created by logging

companies are also important. An audit of 49 logging projects by Groome Poyry (1998:33) confirmed that 30 had delivered infrastructure that qualified as a credit against the required payment of project development levies, worth a total of K43 million.

While rural roads have poverty-reduction benefits (Hughes 2005), logging roads typically have a limited life, given that bridges are only temporary structures and the post-logging maintenance necessary to keep dirt roads functional—especially in undulating country with high rainfall—is absent. The Wawoi Guavi project in Western Province, where Rimbunan Hijau has two timber-processing plants, Panakawa and Kamusie, is one of the few examples where the timber industry can claim to provide relatively enduring regional infrastructure, including roads, airfields, wharves, air services, health clinics and schools (ITS Global 2006). In this article, however, logging for processing is excluded and only the implications for emissions from export logging are dealt with.

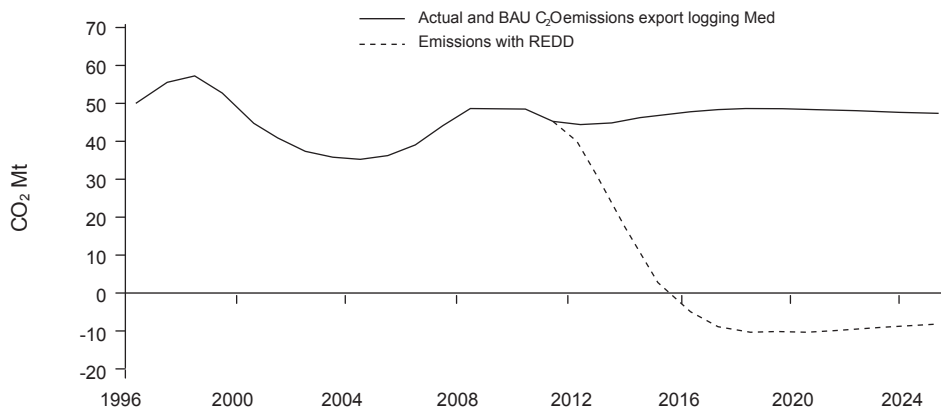
In estimating opportunity costs, it is unlikely that there would be a cessation in logging before 2012 under REDD, given that arrangements would need to be in place, not only for compensation for government and landowner revenues and logging company profits forgone, but also for REDD-plus monitoring, reporting and verification.

## Results for opportunity costs of ceasing logging

The quantity of emissions abated is  $674$  Mt  $\text{CO}_2$  for the 'medium' projection and the average annual abatement is  $35.5$  Mt  $\text{CO}_2$ . Results for the 'high' and 'low' projections are also calculated (Table 1). The present value of opportunity costs for stakeholders for the 'medium' projection are US\$188 million for loggers, US\$224 million for landowners, and US\$228 million for the

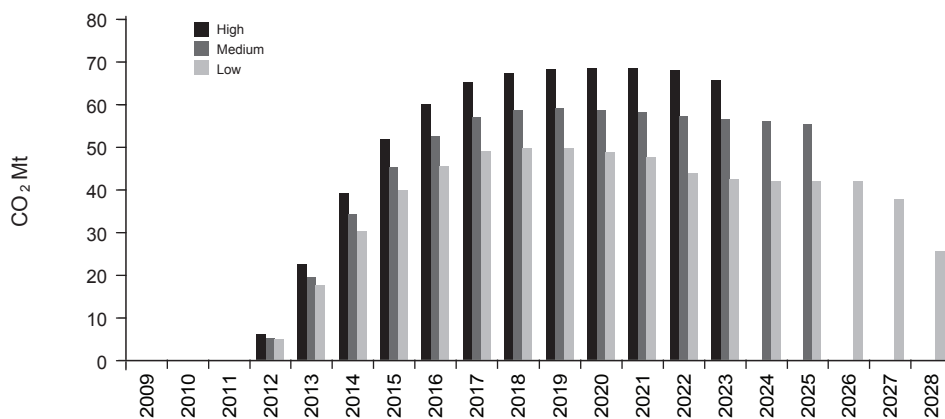


**Figure 3 Emissions BAU and with REDD, medium projections**



**Sources:** Fox, J., Yosi, C. and Keenan, R., 2010. Estimating CO<sub>2</sub> emissions associated with selective timber harvesting and oil palm conversion in Papua New Guinea, Unpublished report and spreadsheets, University of Melbourne, Vic. BAU projections-Colin Hunt.

**Figure 4 Potential abatement from export logging**



**Sources:** Fox, J., Yosi, C. and Keenan, R., 2010. Estimating CO<sub>2</sub> emissions associated with selective timber harvesting and oil palm conversion in Papua New Guinea, Unpublished report and spreadsheets, University of Melbourne, Vic. BAU projections-Colin Hunt.



national government. The present value of the opportunity costs in terms of export income is US\$1.081 billion. The range of opportunity costs for the three levels of projections is in Table 2. The opportunity cost of emissions abated in terms of export income forgone is US\$4.54/t CO<sub>2</sub>, ranging from US\$5.64 to US\$3.40 with a 'medium' estimate of US\$4.54.

### Opportunity costs of ceasing new oil-palm establishment

The quantity of emissions abated for this scenario ranges from 45.4 to 113 Mt CO<sub>2</sub> (Table 3). The opportunity cost to smallholders at the 'medium' projection is US\$77 million, for companies it is US\$179 million, and for government it is US\$104 million, while the opportunity cost in terms of palm-oil export income forgone is US\$714 million. The cost per tonne of abatement in the 'medium' projection for export income is US\$40/t CO<sub>2</sub> with a 'medium' estimate of US\$81.9 Mt.

Results are sensitive to the price of palm-oil. A range above and below the World Bank (2009a) price forecast varies the opportunity costs by plus or minus 10 per cent (Table 4). The cost per tonne of carbon dioxide from palm-oil could be below these estimates if the industry reduces its carbon footprint by establishing one-third of new oil-palm plantations on already cleared land (Personal communication, Ian Orrell, director, PNG Oil Palm Research Association).

The production of fresh-fruit bunches is by company plantations surrounded by smallholders. Company mills—at the operational centres of the nucleus estates—process production from the estate and the peripheral smallholder plantations. The area of oil-palm and the export value of palm-oil—actual and projected—for Papua New Guinea can be mapped (Figures 5 and 6). Expansion of the industry is expected

to continue, given the continuing strong demand for palm-oil and palm-oil products.

The annual reports for only one of the five companies producing palm-oil in Papua New Guinea, New Britain Palm Oil Limited (2008), were publicly available; the annual reports of the four other companies—three owned at the time of writing by Minneapolis-based Cargill—were not accessible. New Britain Palm Oil was, however, responsible for one-half of Papua New Guinea's output and exports. Output, income, government tax and expenditure by the four Papua New Guinea-based palm-oil companies can thus be estimated with a reasonable level of confidence. As for logging companies, the profits of smallholders—which are the basis for compensation—are estimated at 30 per cent of gross income.

The emissions from oil-palm and the abatement achieved by cessation of the establishment of new plantations from 2012 can be calculated (Figure 7), as can be the nominal values of the opportunity costs and the incidence of costs (Figure 8). Actual company net incomes and smallholder gross incomes are derived from company annual accounts and are projected in proportion to the expansion projected in Figures 5 and 6.

The palm-oil companies provide substantial infrastructure and social benefits in the regions in which they are located. A tax credit is available to the companies for approved expenditure on infrastructure; New Britain Palm Oil spent K5.7 million on roads in 2008 under this scheme. In addition, the companies are important providers of education infrastructure and services, as well as public buildings such as police stations and staffed health centres (BSi Management Systems 2008:35). New Britain Palm Oil provides health care for 26,000 people and had total enrolment in its schools of 2,621 in 2008 (New Britain Palm Oil Limited 2008:22, 24). It has not,



**Table 1 Quantity of carbon dioxide emissions abated by cessation of export logging in 2012, at 'high', 'medium' and 'low' projections for the rate of logging (Mt)**

	High	Medium	Low
Total	788	674	658
Average per annum	41.5	35.5	34.6

**Source:** Fox, J., Yosi, C. and Keenan, R., 2010. Estimating CO<sub>2</sub> emissions associated with selective timber harvesting and oil palm conversion in Papua New Guinea, Unpublished report and spreadsheets, University of Melbourne, Vic using BAU projections by Colin Hunt.

**Table 2 Projections of income forgone (present value) by cessation of export logging in 2012 (US\$ million)**

	High	Medium	Low
Logger net income	255	188	129
Landowner royalty	69	65	58
Landowner development benefit	188	159	93
Government	295	228	156
Export income	1400	1081	735

**Note:** Stakeholder shares of export income are determined by regulations and legislation and applied to BAU projections by Colin Hunt.

**Table 3 Quantity of carbon dioxide emissions abated by cessation of conversion to oil-palm, 2012–37 (Mt)**

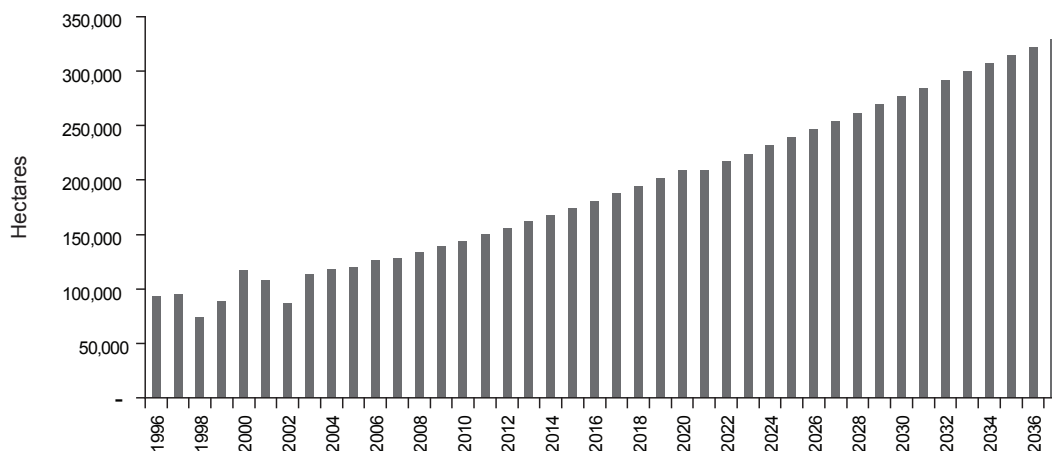
	High	Medium	Low
Total	113.0	81.9	45.4
Average per annum	4.0	2.9	1.6

**Source:** Fox, J., Yosi, C. and Keenan, R., 2010. Estimating CO<sub>2</sub> emissions associated with selective timber harvesting and oil palm conversion in Papua New Guinea, Unpublished report and spreadsheets, University of Melbourne, Vic using BAU projections by Colin Hunt.

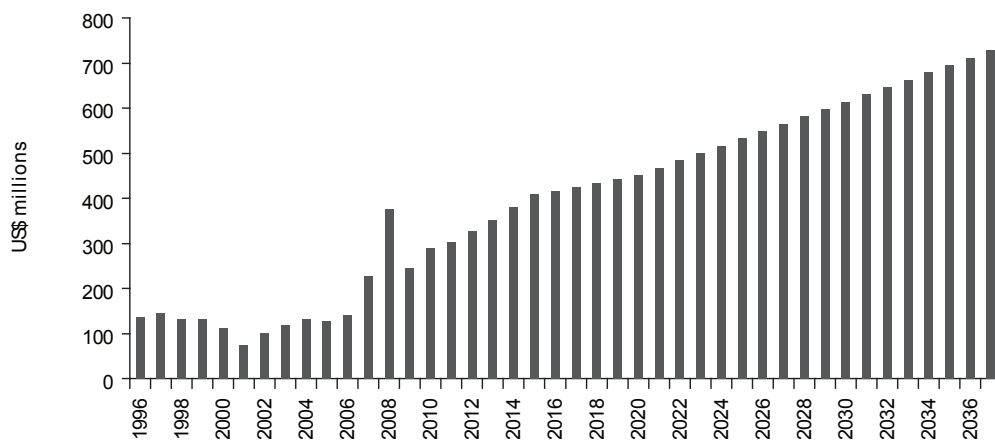
**Table 4 Projections of income forgone (present value) per tonne of carbon dioxide abated by cessation of oil-palm establishment in 2012 (US\$ million)**

	High	Medium	Low
Smallholders (net income)	85	77	69
Companies (net income)	197	179	161
Government tax	115	104	94
Export income	784	714	643

**Sources:** Stakeholder incomes and government tax are based on New Britain Palm Oil Limited, 2008. Annual Report of New Britain Palm Oil 2008, New Britain Palm Oil Limited, Kimbe, West New Britain. Available from [http://www.nbpol.com.pg/downloads/Annual\\_Report\\_2008\\_FINAL.pdf](http://www.nbpol.com.pg/downloads/Annual_Report_2008_FINAL.pdf) (accessed 15 October 2009). BAU projections by Colin Hunt.


**Figure 5 Area of oil-palm, actual to 2008, BAU projected to 2037**


**Sources:** Actual—Personal communication, Ian Orrell, director, PNG Oil Palm Research Association; BAU projection—Colin Hunt.

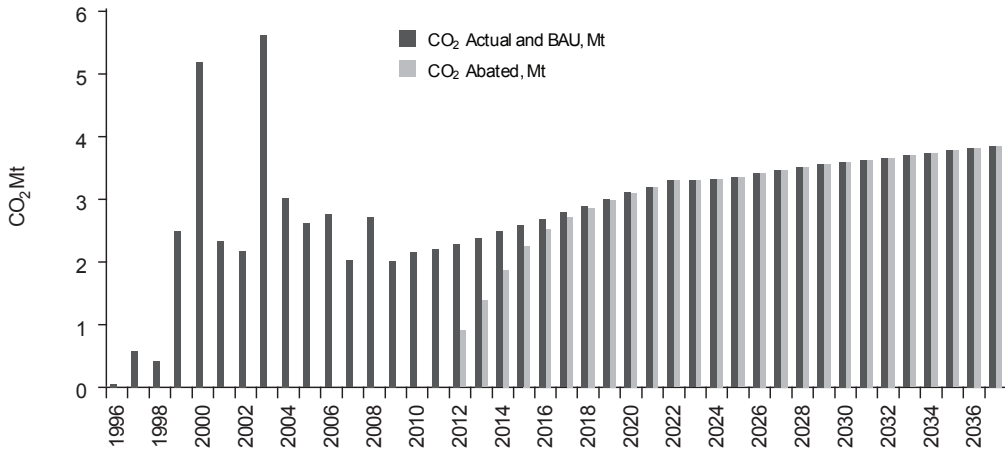
**Figure 6 Value of palm-oil exports, actual to 2008, BAU projected to 2037**


**Sources:** Actual—Bank of Papua New Guinea (BPNG), Various years. *Quarterly Economic Bulletin*, Bank of Papua New Guinea, Port Moresby; price projections—World Bank, 2009a. *Global Commodity Markets*, The World Bank, Washington, DC; BAU projection—Colin Hunt.



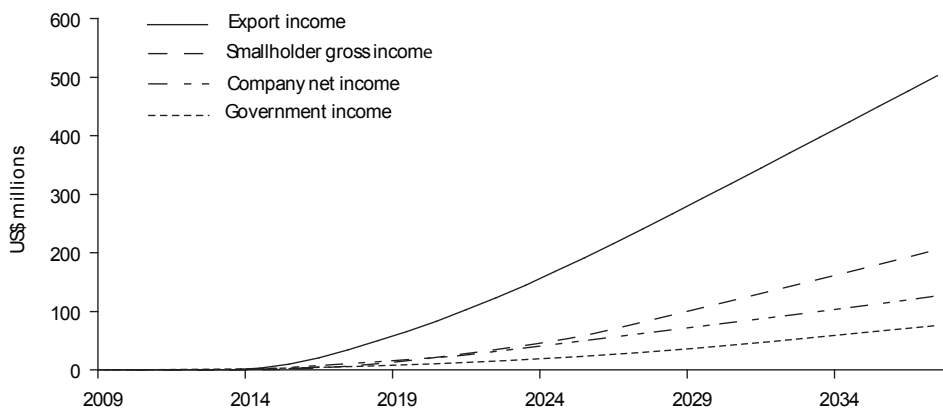


**Figure 7 Carbon dioxide emissions from oil-palm, actual to 2008, medium BAU projected to 2037 and abated from 2012**



**Sources:** Fox, J., Yosi, C. and Keenan, R., 2010. Estimating CO<sub>2</sub> emissions associated with selective timber harvesting and oil palm conversion in Papua New Guinea, Unpublished report and spreadsheets, University of Melbourne, Vic; BAU projection-Colin Hunt.

**Figure 8 Opportunity costs of cessation in expansion of oil-palm, 2012–37, nominal values**



**Source:** Author estimates.



however, been possible in the scope of this article to quantify the annual financial contribution of PNG palm-oil companies to social infrastructure.

The expansion of oil-palm forecast in this article does not include proposed so-called agro-forestry projects. Their status is uncertain, given that most projects are for oil-palm but are located where there is no mill infrastructure and are therefore unlikely to proceed.<sup>7</sup>

### **Regional economic impacts and socioeconomic costs of REDD**

New Britain Palm Oil Limited's (2008) expenditure on goods (including the purchase of the output of smallholders) and services and wages was US\$168 million in 2008, and, from 2004 to 2008, it averaged three times the level of net profits. Therefore, total expenditure on goods and services by palm-oil companies is likely to have been in the region of US\$300 million in 2008. A proportion of this expenditure would be on imports; but a proportion would also be made directly at the regional level (on wages, fresh fruit, repairs and maintenance, transport, and so on), resulting in an economic impact. The regional benefits of palm-oil are thus larger than indicated simply by the size of palm-oil company profits. Logging company expenditure at the regional level will also have an economic impact—albeit less than that of palm-oil companies given the transitory nature of logging—but this impact cannot be illustrated due to the unavailability of logging company annual accounts.

The employment impact of a cessation in logging in Papua New Guinea is illustrated by the Food and Agriculture Organisation (FAO 2005) estimate that 8,000 workers at any one time receive monetary benefits through the provision of labour to

logging companies. In the case of the palm-oil industry, there were almost 14,000 PNG nationals employed in 2008, as well as 52,000 smallholders involved in supplying the mills (Personal communication, Ian Orrell, director, PNG Oil Palm Research Association). An illustration of the social costs incurred by the cessation of new oil-palm plantings in 2012 is the forecast that the loss in employment for PNG nationals would peak at 4,000 and the loss in smallholder gross receipts would peak at more than US\$70 million as a result (Figure 9). (please contact the author at [c.hunt@uq.edu.au](mailto:c.hunt@uq.edu.au) for projections.) Oil-palm takes a few years to become productive after establishment, hence the sigmoid curves representing gross income and employment forgone from 2012 in Figure 9. (No estimate is made for the increase in the number of smallholders, as this will depend on the expansion in area planted by existing smallholders.)

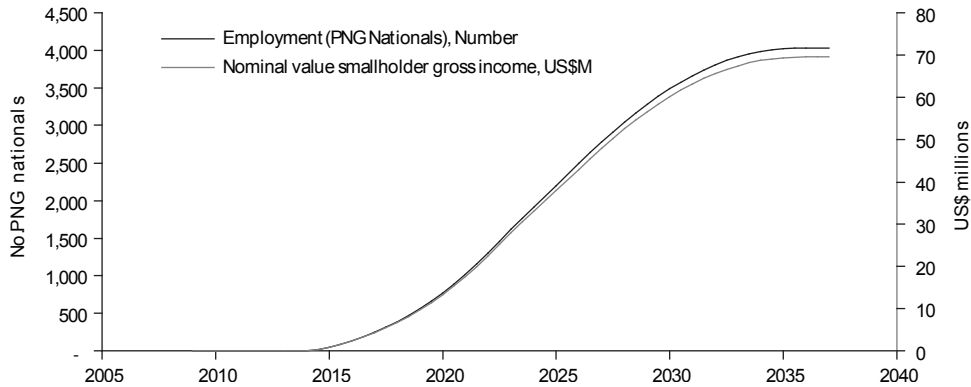
The majority—87 per cent (Bourke and Harwood 2009)—of the PNG population is rural and the rate of population growth is 2.4 per cent (World Bank 2010), implying a doubling of the population in 30 years. Demand for land for cash cropping such as oil-palm and subsistence agriculture is bound to increase. There is a danger that the preservation of large areas of forest could impede cash generation and the maintenance of livelihoods. To avoid such perverse outcomes, the regional implications of the REDD scheme need to be investigated.

### **Issues in compensation**

The PNG government must be concerned that compensation is paid at a level that generates at least a similar level of national income and livelihoods to that forgone (Pagiola and Bosquet 2009). The administration of a REDD scheme in Papua New Guinea faces particular challenges in the



**Figure 9 Projections of employment and nominal value of smallholder gross income forgone with cessation in conversion to oil-palm, 2012–37**



Source: Author estimates.

negotiation of compensation that is equitable for the customary owners of the forest resource. While REDD needs to be coordinated nationally to avoid inter-regional leakage in emissions, funding could be either through the national government or channelled directly to regions. Up to now, a policy vacuum has allowed unscrupulous carbon traders to exploit the naiveté of landowners (Mellick 2010). The task faced is the effective distribution of the funds or making investments on behalf of landowners. It is estimated that logging will generate US\$11 million in royalties and US\$26 million in PDBs in 2012 (see Figure 2 and Appendix 1 for compulsory levies and supplementary information about their projections). In the case of PDBs, funds are set aside by the PNG Forest Authority (PNGFA) and administered by committees; but this has proved to be an ineffective vehicle for regional development (Filer 2009). It should be emphasised that the forest resource in each incorporated landowner group (ILG) is logged out in one or two years, so that the cash benefits through royalties are temporary. There is a limited range of investment opportunities

locally, and the absence of local banking services hampers household and collective community investment and savings. Much of the money received is spent in a way that produces little visible long-term benefit, and spin-off businesses die when the project they rely on is completed (PNGFIA 2007). An effective model needs to be developed for the deployment of REDD funds.

The nature of the infrastructure benefits of logging was discussed earlier. Lack of information on infrastructure inventories and values precludes the inclusion of the opportunity costs of infrastructure associated with logging and oil-palm in this analysis. Nevertheless, in practice, a premium could be paid to landowners—over and above royalty and development levies—to compensate for infrastructure forgone.

Given that forest resources and land converted from forest will be out of bounds after the cessation of logging under REDD, the availability of regional investment alternatives is unclear. Rather than invest in REDD compensation funds that might not be successful, an alternative is for the REDD scheme to pay landowners annuities



in cash and allow them to make their own investment decisions. But cash annuities in small amounts—in contrast with log royalties, which come in a lump sum—are more likely to be consumed than saved and invested. But, as ITS Global (2009) points out, it is unrealistic to expect landowners to be able to assess the long-term opportunity costs of REDD. This again highlights the need for regional studies of development opportunities and delivery mechanisms under a REDD scheme.

Another difficult issue that needs to be resolved is the scheduling of landowner compensation. Landowners in concessions soon to be logged under BAU could expect compensation in the near term for royalties and development benefits forgone. For future logging, however, there is the difficulty of forecasting when particular concessions will be opened and the pattern of logging within them, and consequently when landowners whose trees are felled would be entitled to compensation. To overcome this problem, as well as the problem of a decline in the real value of royalties and development benefits over time due to inflation, all landowners could receive compensation under a negotiated settlement at the commencement of the scheme. Such up-front payments of compensation would, however, conflict with the need for the donor to be satisfied that promised abatement was achieved in each year.

As well as difficulties of timing, there are also risks in the administration of REDD funds—broadly illustrated by the ranking of Papua New Guinea at 154 out of 180 countries in the Transparency International (2009) corruption index; and a ranking of 10—where 1 is low control and 100 is high—in the World Bank (2009b) control-of-corruption index.

The risk that surrounds the deployment of REDD funds for the benefit of landowners is illustrated by a case of misappropriation

or faulty accounting with respect to the landowner development funds sourced from log export revenues. The *Post-Courier* ('K4 mil. forest levies unaccounted for', 29 September 2009) reported that the Gulf provincial government had failed to account for some K2.6 million received in log export development levies in 2007 and K2.1 million received in 2008 from five projects.

The obvious risks to potential donors of investing in REDD in Papua New Guinea are likely to weigh heavily on donor decisions. As ITS Global (2009) points out, a slump in the price per tonne of carbon, in the absence of binding emission targets post-Copenhagen, is also likely to have affected the price REDD donors are willing to pay for sequestered carbon in PNG. A risk discount applied to the price for carbon emissions abated that reduced compensation below opportunity costs would probably not be well received by PNG stakeholders. In making their REDD investment decisions, donors are likely to compare the risk across countries and invest where the carbon price and risk are relatively low.

## Baselines and moral hazard

Tropical developing countries will be tempted to inflate their BAU projections of deforestation in order to maximise their compensation. A case of this seems to exist in Papua New Guinea. In its 'preliminary inscription', forwarded to the UN Framework Convention on Climate Change under the Copenhagen Accord, Papua New Guinea claims that carbon dioxide emissions from forestry are estimated to be 50–52 Mt in 2010, that these will increase to 53–64 Mt by 2030, and that the abatement that can be delivered by 2030 is 50 per cent of this volume—that is, 26–32 Mt. Agriculture is also expected to expand greatly, creating a large abatement potential of 15–27 Mt/pa by 2030 (Conrad 2010:4).



While present emissions from export logging are estimated to be 48 Mt (Fox, Yosi and Keenan 2010)—which is roughly in line with the government's figure—the increase to 2030 from logging suggested by the PNG government is unrealistic, given that, as discussed, the accessible resource could be exhausted several years before that time at current rates of exploitation.

The proposition that emissions from subsistence agriculture can form part of the large abatement has already been discussed. First, subsistence agriculture is already efficient and, second, the government has no control over subsistence agriculturalists tilling their own land. No accurate emission data exist for the bulk of commercial and smallholder agricultural production, with the exception of oil-palm, which, by far the fastest growing agricultural crop, still generates total emissions of only 3.85 Mt CO<sub>2</sub> by 2030 (Figure 7). Up to one-third of new plantings could be expected to be accommodated on already cleared land, which delivers the limited abatement of 1.28 Mt CO<sub>2</sub>. The abatement potential from agriculture would thus seem to be a good deal less than the 15–27 Mt claimed by the PNG government.

## Conclusions

This study confirms the view of Howes (2009) that for Papua New Guinea the reduction in greenhouse emissions from land-use change and forestry (LUCF) will be cheap—at least in the case of logging for export—but will not be easy. These conclusions are reached through the application of financial modelling and by integrating the results with the results of recent research on carbon dioxide emissions generated by the selective logging of primary forest and from growing oil-palm that replaces selectively logged forest. Modelling of industries

enables the estimation of the present value of BAU stakeholder and export incomes, as well as the BAU value per tonne of carbon dioxide emissions abated. In the case of logging, the forecasts are for 2012 to 2023–28,<sup>8</sup> and, in the case of palm-oil, for 2012–37. It should be noted that cost estimates do not include the costs of administering REDD.

A criticism of the method is that the opportunity costs of REDD have been overestimated to the extent that income generated by enterprises that might replace logging and palm-oil have been ignored. Other sources of error are the estimations of the profits of logging companies. The omission of income tax paid by logging companies—which inflates logging company profits and deflates government tax receipts by an equal amount—was forced on the analysis by lack of data. The PNG government will have access to logging company income tax returns and will be able to better estimate profits.

Export incomes to Papua New Guinea under BAU, and hence the opportunity costs of REDD, could also change relative to the projections made in this article; export incomes could increase as a result of a reduction in worldwide deforestation rates, or decrease as a result of the appreciation of the kina relative to the US dollar.

There is also overstatement of the abatement achieved by REDD due to the variable rates of sequestration in regenerating forest of different age classes. The method of analysis, however, minimises this error.<sup>9</sup> At the same time, the exclusion of the value of infrastructure benefits provided by logging and palm-oil companies underestimates opportunity costs.

Notwithstanding the deficiencies of the analysis, it can be concluded that it appears feasible to design a compensation package for REDD in the case of logging based on BAU incomes. In contrast, in the case of oil-palm, stakeholder and national opportunity



costs are sufficiently high to rule out REDD as an economical option, unless there is a marked rise in the international prices paid for carbon dioxide emissions abated. While the opportunity cost of REDD in the case of logging will likely be higher than hitherto suggested,<sup>10</sup> its price is still what could be considered 'reasonable' and it delivers a large quantity of abatement.

The amount of compensation varies between stakeholders depending on the nature of the benefit—that is, shares of export income for government and landowners, based on legislation and regulation, and net profit in the case of logging companies. Given that a donor would want proof of abatement, it would be best that compensation is paid annually. These payments compensating for opportunity costs (under the 'medium' projection of BAU incomes) would average US\$214 million per annum in nominal terms for the years 2012–25 and total US\$2.790 billion, which has a present value of US\$1.081 billion (at a 10 per cent discount rate) (please contact the author at c.hunt@uq.edu.au for the projections of BAU incomes).

It is clear that enormous challenges face Papua New Guinea in the design of management arrangements that effectively deliver REDD compensation, particularly in the case of payments to the customary landowners. Donors would need to be satisfied that REDD compensation was indeed enhancing rather than disadvantaging the welfare of regional communities and that funds were being used wisely. Further research is needed to identify the mechanisms by which compensation payments could be made equitably and in a way that would benefit communities and the economy more generally. This could extend the planning time required for REDD beyond the period envisaged in this article.

## Appendix 1: Compulsory levies on export logs

### Royalties

Paid to landowners on whose land the trees were felled, at a fixed rate for each species and thus varying with the species mix being harvested. It is estimated that the Papua New Guinea-wide payment averages K13.86/cu m before allowing for a government withholding tax of 5 per cent (Personal communication, Bob Tate, executive officer, PNGFIA). Changes can be made by ministerial notice to each permit holder.

### Project development benefit (PDB)

A progressive levy based on free-on-board (FOB) values. The levy is collected by the National Forest Service and distributed on the basis of outcomes of the responsible committees, with the proportions of cash and development funds negotiable. The PDB replaced the producer development levy that specified the proportions of cash and development funds payable.

### Log export development levy

A flat tax at K8/cu m exported (plantation logs exempt). Administered by central government agencies and distributed on the basis of proposals submitted by provincial and local area governments (*Forestry [2007 Budget Amendment] Act 2006*, of the *Forestry Act 1991*:s. 121A, Log Export Development Levy.)

### Log export tax

A flat rate of 28.5 per cent of FOB values (plantation logs exempt) (*Customs Tariff [2007 Budget Amendment] Act 2006*:s. 3).

### Reforestation levy

An amount of K2/cu m raised by the PNG Forest Authority (PNGFA). Previously, 60





per cent was applied to the project area and 40 per cent to PNGFA-owned plantations, but its allocation is now at the discretion of the PNGFA.

### Agricultural and 'other' levies

Negotiated at project commencement and dispersed by provincial governments.

### Notes

- <sup>1</sup> More recent estimates are that deforestation and degradation generate about 12 per cent of anthropogenic carbon dioxide emissions (Le Quéré et al. 2009).
- <sup>2</sup> The underpinning principles of REDD-plus are detailed at The Forests Dialogue (2010). A market approach to REDD requires that 1 tonne of carbon dioxide abated by forest conservation equates to 1 tonne abated by all other means. Given the idiosyncrasies of forests, this will be difficult to guarantee; therefore, a funds-based approach is more appropriate until the problems of abatement by REDD—in terms of monitoring, verification and reporting—are solved (Hunt 2009).
- <sup>3</sup> This level of aboveground carbon is lower than estimates for equivalent forests in Southeast Asia, where estimates are for 240–60 t/ha (Fox et al. 2010:6).
- <sup>4</sup> Harvesting is selective in that logging companies concentrate on removing high-value species with diameters greater than 50 cm.
- <sup>5</sup> One tonne of C = 3.67 tonnes of CO<sub>2</sub>.
- <sup>6</sup> The income tax on profits has not been established; this estimate of net profit is therefore before tax.
- <sup>7</sup> Special agricultural and business leases (also called agro-forestry projects) have recently been granted to private companies that have a combined area of 1.5 million ha and are mostly not already logged (Filer 2009:23–5). Such projects require infrastructure. In the case of oil-palm development, the need is for a palm-oil mill in proximity to the plantations—necessitating a very large investment. Nevertheless, as Filer (2009) points out, if two or three of these projects evolve into large-scale developments, the prospect is for even higher growth than has been forecast in this article.
- <sup>8</sup> While logging ceases in 2025 under the 'medium' projection, it ceases earlier (in 2023) in the case of the 'high' projection and later (in 2028) in the case of the 'low' projection, given that the finite resource is exploited at differential rates.
- <sup>9</sup> The modelling assumes that there is no abatement benefit after the logs are exhausted. Re-growth is, however, still sequestering carbon 100 years after logging and the rate of carbon sequestration is not constant over time; sequestration exhibits a sigmoid tendency with faster rates from five to 20 years after logging (Fox, Yosi and Keenan 2010). After the end of the modelling period (2025, in the case of the 'medium' projection), the sequestration rate will be higher in forest logged under BAU than for forest last logged in 2011 under REDD. While the abatement benefit of REDD is overstated, the discounting method adopted in calculating the cost per tonne gives abatement in the future a lesser value than abatement in the present, thus the error is minimised.
- <sup>10</sup> Grieg Gran (2006), in a report to Stern (2006), estimated the opportunity costs of a cessation in logging in Papua New Guinea at US\$5/t CO<sub>2</sub> abated; Busch et al. (2009) suggested a cost of US\$2.24/t CO<sub>2</sub> for Papua New Guinea, while a survey by Olsen and Bishop (2008) found the financial cost of logging in Southeast Asia and the Pacific to be US\$3.44/t CO<sub>2</sub>, and Boucher (2008) found a similar level of average cost of US\$2.90/t CO<sub>2</sub>. Previously inflated data on carbon emissions from PNG LUCF (WRI 2009) could have resulted in these low costs. These estimates should also be treated with caution because the method adopted has a large bearing on cost (Richards and Stokes 2004).



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